

TM-71-2015-1

TECHNICAL MEMORANDUM

NEAR TERMINATOR PHOTOGRAPHY
(WITHIN $1/2^\circ$) OBTAINED ON APOLLO 14

Bellcomm

N79-72878

(NASA-CR-118418) NEAR TERMINATOR
PHOTOGRAPHY / WITHIN $1/2^\circ$ DEG/ OBTAINED ON
APOLLO 14 (Bellcomm, Inc.) 12 P

00/35 12849
Incl as

FF No. 602 (

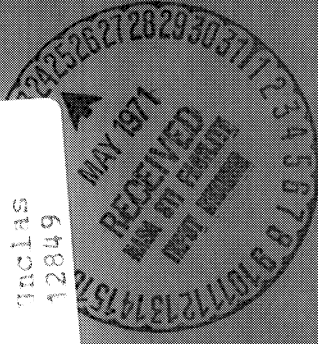
(PAGES)

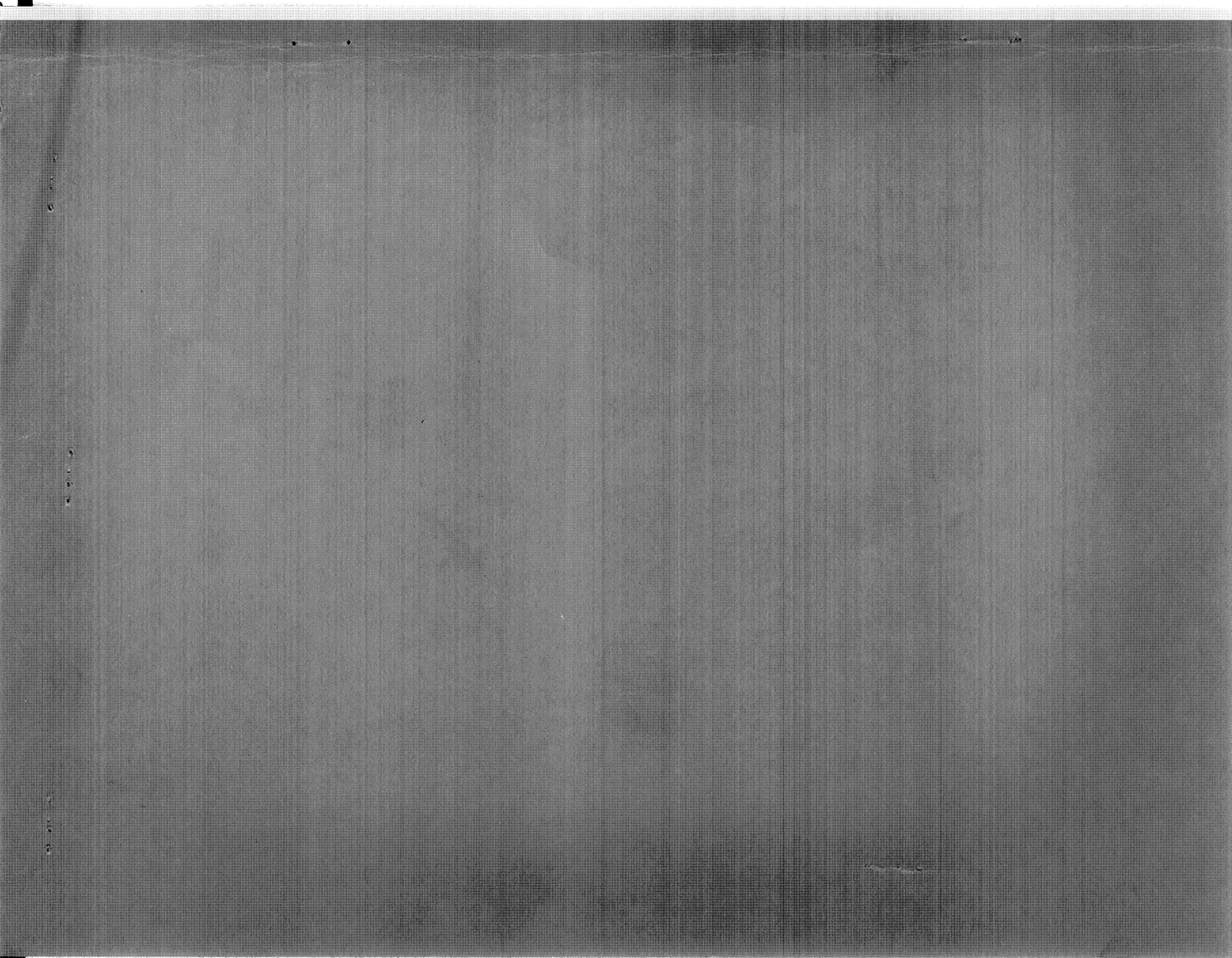
CR-118418

(NASA CR OR TMX OR AD NUMBER)

(CODE)

(CATEGORY)





BELLCOMM, INC.

955 L'ENFANT PLAZA NORTH, S.W., WASHINGTON, D.C. 20024

COVER SHEET FOR TECHNICAL MEMORANDUM

TITLE- Near Terminator Photography
(within $1/2^\circ$) Obtained on Apollo 14

TM-71-2015-1

DATE- April 20, 1971

FILING CASE NO(S)- 340

AUTHOR(S)- D. D. Lloyd

FILING SUBJECT(S) Lunar Geology
(ASSIGNED BY AUTHOR(S))- Lunar Terminator Photography

ABSTRACT

A sequence of four photographs were obtained on Apollo 14 of an area of the lunar surface when that area was coincident with a sunrise terminator. The photographs are of maria south of the crater Kunowski; the center of the photographic target is about 2°N and 32.5°W . The area within $1/2^\circ$ of the terminator shows wide variation of scene contrast. It is possible to recognize small (considerably less than $1/2^\circ$) variations in slope of those portions of the surface that are nearly tangential to the local sun. Many geological features stand out in a manner that is not normal in conventional lunar photography. Stereo viewing, of pairs within the sequence of four photographs, aids recognition of the nature of any feature examined.

This special near-terminator photography from Apollo 14 was considered experimental. The extent to which such photography will be planned for future lunar missions is a function of scientific reaction to these first results.

DISTRIBUTIONCOMPLETE MEMORANDUM TO

CORRESPONDENCE FILES:

OFFICIAL FILE COPY

plus one white copy for each
additional case referenced

TECHNICAL LIBRARY (4)

NASA Headquarters

R. J. Allenby - MAL
D. A. Beattie - MAL
G. F. Esenwein - MAL
L. J. Kosofsky - MAL
A. S. Lyman - MR
W. T. O'Bryant - MAL
F. I. Roberson - MAL
L. R. Scherer - MAL

Manned Spacecraft Center

G. A. Coultas - PG
J. W. Dietrich - TJ
P. W. Gast - TN
S. N. Hardee - TM
N. T. Lamar - BL
M. C. McEwen - TM
A. W. Patteson - TJ
W. C. Phinney - TN
S. A. Roosa - CB
R. W. Underwood - BL
J. G. Zarcaro - TM

Goddard Space Flight Center

L. Dunkelman - 673

U. S. Geological Survey

F. J. Doyle/Washington
H. Masursky/Flagstaff
J. McCauley/Flagstaff
D. E. Wilhelms/Menlo Park

University of California

W. Kaula

University of Massachusetts

D. Wise

COMPLETE MEMORANDUM TOUniversity of Arizona

E. Whitaker

U. S. Topographic Command

D. Light

Dudley Observatory

R. Mercer

Aeronautical & Chart Inf. Ctr.

L. Schimmerman

Coast & Geodetic Survey

H. Schmid

Bellcomm, Inc.

R. A. Bass
A. P. Boysen, Jr.
J. O. Cappellari, Jr.
F. El-Baz
D. R. Hagner
W. G. Heffron
J. J. Hibbert
N. W. Hanners
T. B. Hoekstra
M. Liwshitz
J. L. Marshall
K. E. Martersteck
J. Z. Menard
G. T. Orrok
P. E. Reynolds
P. F. Sennewald
R. V. Sperry
A. W. Starkey
J. W. Timko
A. R. Vernon
R. L. Wagner
D. B. Wood
All Members Dept. 2015
Central Files
Dept. 1024 Files

ABSTRACT ONLY TO

Bellcomm, Inc.

J. P. Downs
D. P. Ling
M. P. Wilson



Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: April 20, 1971

to: Distribution

TM-71-2015-1

from: D. D. Lloyd

subject: Near-Terminator Photography
(within $1/2^\circ$) Obtained on Apollo 14 --
Case 340

TECHNICAL MEMORANDUM

1.0 INTRODUCTION

For many years it has been widely accepted that an examination of the lunar surface under near-terminator lighting conditions is extremely valuable to geologists and other scientists. Prior to the era when lunar photography could be obtained from spacecraft in lunar orbit, a large percentage of the telescopic observation of the moon (both directly and via photography) was carried out when the part of the moon of interest was under near-terminator lighting conditions. When unmanned spacecraft whose prime mission objective was lunar photography were flown (e.g., Lunar Orbiter), the mission parameters were selected to produce photography near the terminator. One reason for this is that under near-terminator conditions (low sun elevation) small changes in slope produce greater contrast changes than at high sun elevation angles. A related desirable phenomenon is that at low sun elevation the shadow is longer than the object is high, thus increasing certain information about the object. For example, at 20° the exaggeration is 2.75 ($\cotan 20^\circ$) thus increasing detectability and morphologic identification.

Historically it has been difficult to obtain photography nearer the terminator than about 8° without severe underexposure. The Lunar Orbiter and the Panoramic Camera (planned for Apollos 15, 16, and 17) were optimized for photography at 20° or above in maria* and neither can produce the desired mid-range exposures when operating nearer the terminator than 8° (although some lunar farside photography from Lunar Orbiter IV was perhaps highly useful in certain regions nearer the terminator).

*In highlands they can operate at lower sun elevations due to the higher albedo.



Faster films could be used to obtain photography nearer the terminator than 8° but such fast films pay a resolution penalty which for most unattended camera systems would be paid for in all the photography obtained during the mission, i.e., the film selected for photography at, say, $1/2^\circ$ from the terminator would also be used for all the other photography.

The ability of an astronaut to change films in the Hasselblad cameras provided an opportunity on Apollo 14, and will provide future opportunities on Apollos 15, 16 and 17 for use of very high speed films. Despite the fact that there was no image motion compensation normally* available for these cameras it seemed possible that a film could be selected capable of photography within $1/2^\circ$ of the terminator at a resolution that might provide lunar photography of special geological interest. The shadow length at $1/2^\circ$ from the terminator would be greater than the height of any object by a factor of 114.6 ($\cotan 1/2^\circ$). Slight variations (less than $1/2^\circ$) in slopes near horizontal would produce significant variations in scene contrast.

TECHNICAL DISCUSSION

Operation

A sequence of photographs was taken on rev 19 of Apollo 14 starting a few minutes prior to crossing of the sunrise** terminator and continuing past the terminator. These photographs were taken at the request of the author as part of the Photo Team activities. Figure 1 shows the location of the area covered.

The camera used was the Hasselblad Data Camera with the 80 mm lens. The timing sequence was set to provide approximately 60% forward overlap by exposing at 20 second intervals. The camera f# was set at 2.8 and the exposure time was $1/60$ secs. The film used was Kodak 2485 which is a very high speed black and white film. The spacecraft was oriented for vertical photography. The operation was carried out by Lt. Col. Roosa, CMP, as specified in the mission requirements document.

*Image motion compensation can be obtained by rotation of the spacecraft.

**The term "sunrise" is used here in its normal sense i.e., as it appears to an observer on the surface, In certain operational documents, it is called sunset as the spacecraft moves from light to dark.



Results

Four photographs are of special interest. These are on Magazine S. Their identification numbers are AS14-78-10375/6/7 and 8. Poor quality copies of these photographs are attached as Figures 2 through 5. High quality copies are with the author. The field of view of each covers an area of approximately $2\frac{1}{2}$ lunar degrees by $2\frac{1}{2}$ lunar degrees (80 km E-W x 76 km N-S).

The photographs AS14-78 10376/7&8 show the terminator. Photograph AS14-78-10377 is particularly impressive. It is centered at approximately 2°N and 32.5°W . The southern half of the crater Kunowski appears at the top center of the frame. The terminator passes approximately through the center of the crater Kunowski and near terminator photography, say $\pm 1/2^{\circ}$, occupies the middle third of the picture. This center portion of photograph 10377 can be viewed in stereo using appropriate sections of photographs 10376 and 10378.

Comment

If the photograph 10377 were to be examined without prior knowledge of the area south of Kunowski the lunar surface would probably be described as appearing undulating and rough. But one's perceptual filters must be recognized as controlled by recognition models formed by prior experience which prior experience has never included useful photography within $1/2^{\circ}$ of the terminator.

The area of the lunar surface covered by photograph 10377 is shown in the attached print of approximately the same area from Lunar Orbiter IV high resolution frame #133 section 3, (Figure 6). The area south of Kunowski is seen to be maria and only a minor ridge pattern, or higher albedo suggestion of a ray, is seen in much of the area. It is clear that photography within $1/2^{\circ}$ of the terminator produces an exaggeration of gentle surface slopes and other surface features and enables examination of surface characteristics that might not normally be observable.

Conclusions

Four unusual photographs were obtained that showed lunar surface areas within $1/2^{\circ}$ of the terminator that were certainly of pictorial interest. Many geological features stand out in a manner not normal in conventional lunar



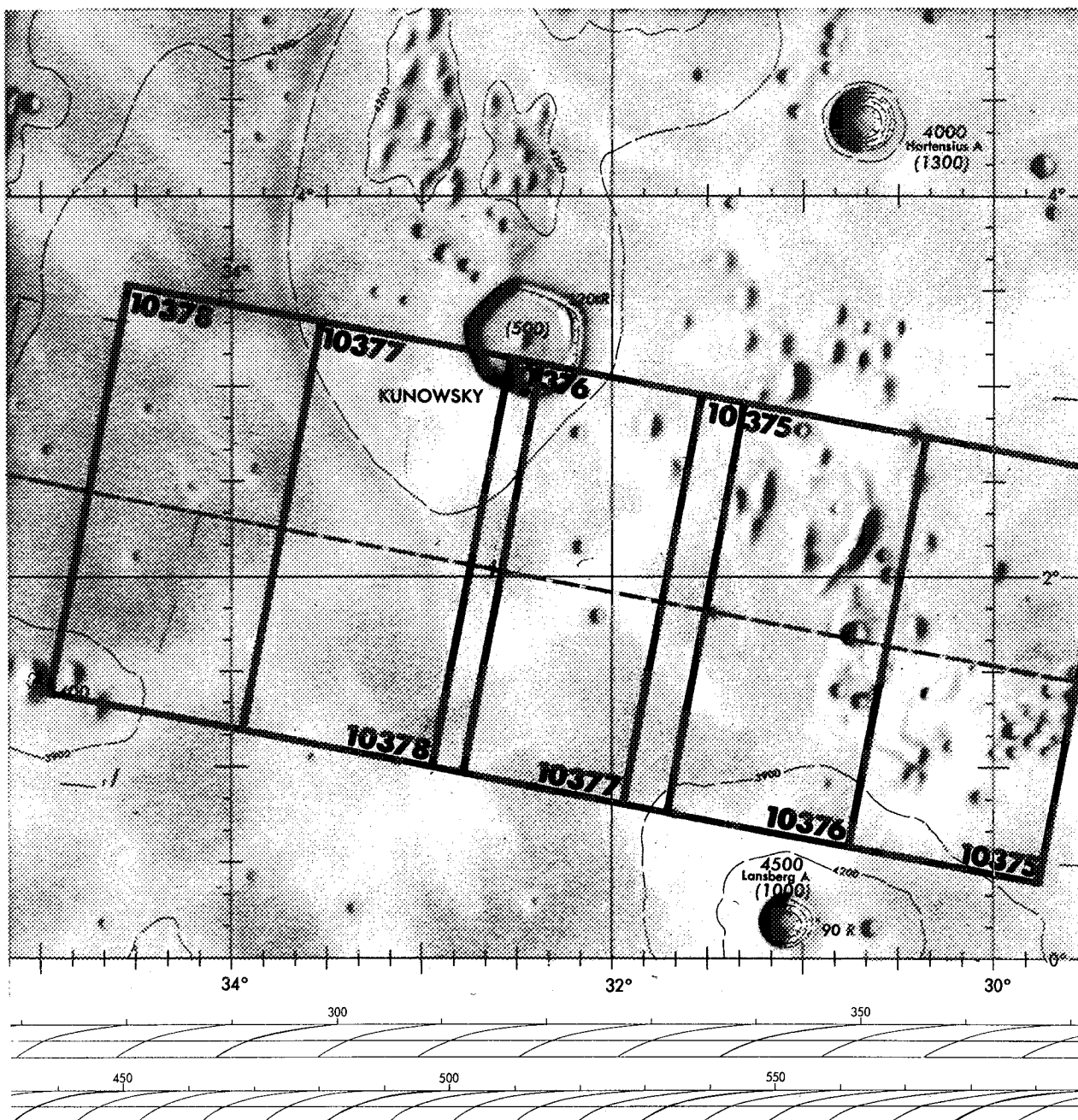
photography. For a distance of approximately $1/2^\circ$ from the terminator variations in surface slopes that are within $1/2^\circ$ of the horizontal produce significant changes in contrast which enables the brain to "see" these variations. Craters and other features produce shadows that on first impression seem to highly exaggerate the height of the feature.

This special near terminator photography from Apollo 14 was considered experimental. The extent to which such photography will be planned for future missions, and how it will be optimized, are a function of scientific reaction to these first results.

D. D. Lloyd
D. D. Lloyd

2015-DDL-dmu

Attachments
Figures 1-6



For Sale by the Superintendent of Documents,
U. S. Government Printing Office,
Washington 25, D. C. Price 50 cents

KEPLER
LAC 57

SCALE 1:1,000,000
2ND EDITION MAY 1962

FIGURE 1 — PHOTO FOOTPRINT ON LAC CHART

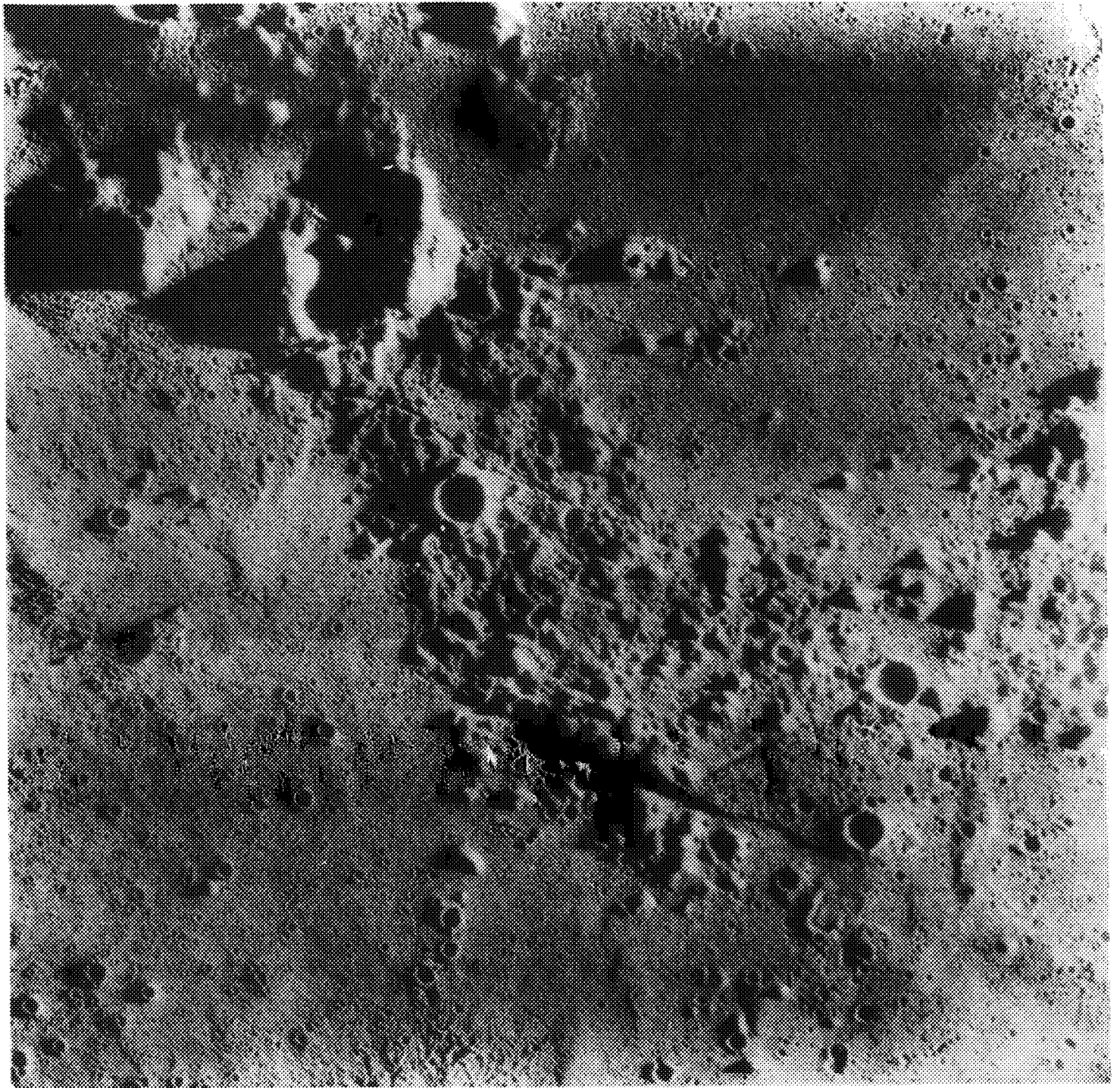


FIGURE 2 - AS14-78-10375

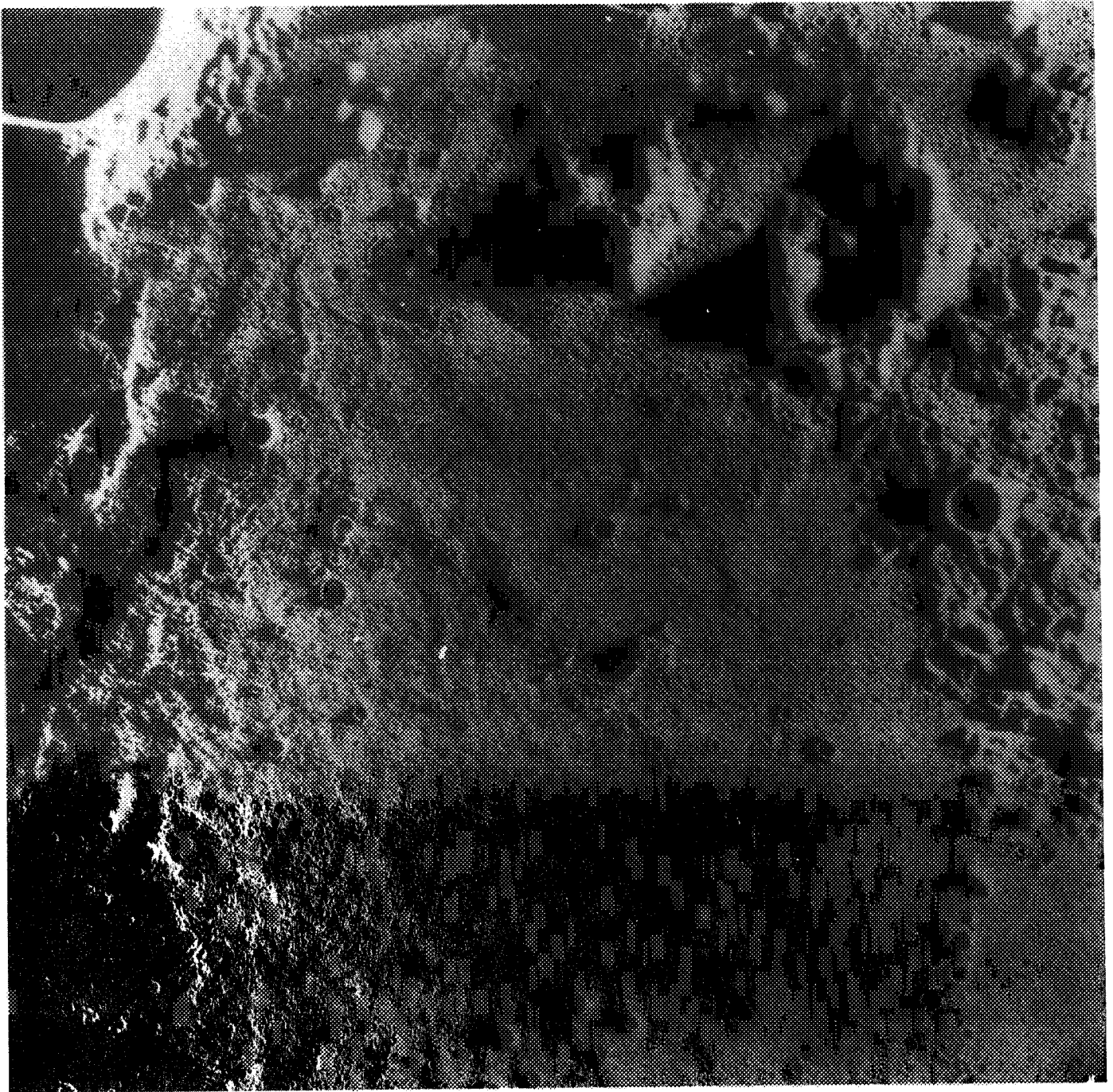


FIGURE 3 - AS14-78-10376



FIGURE 4 - AS14-78-10377

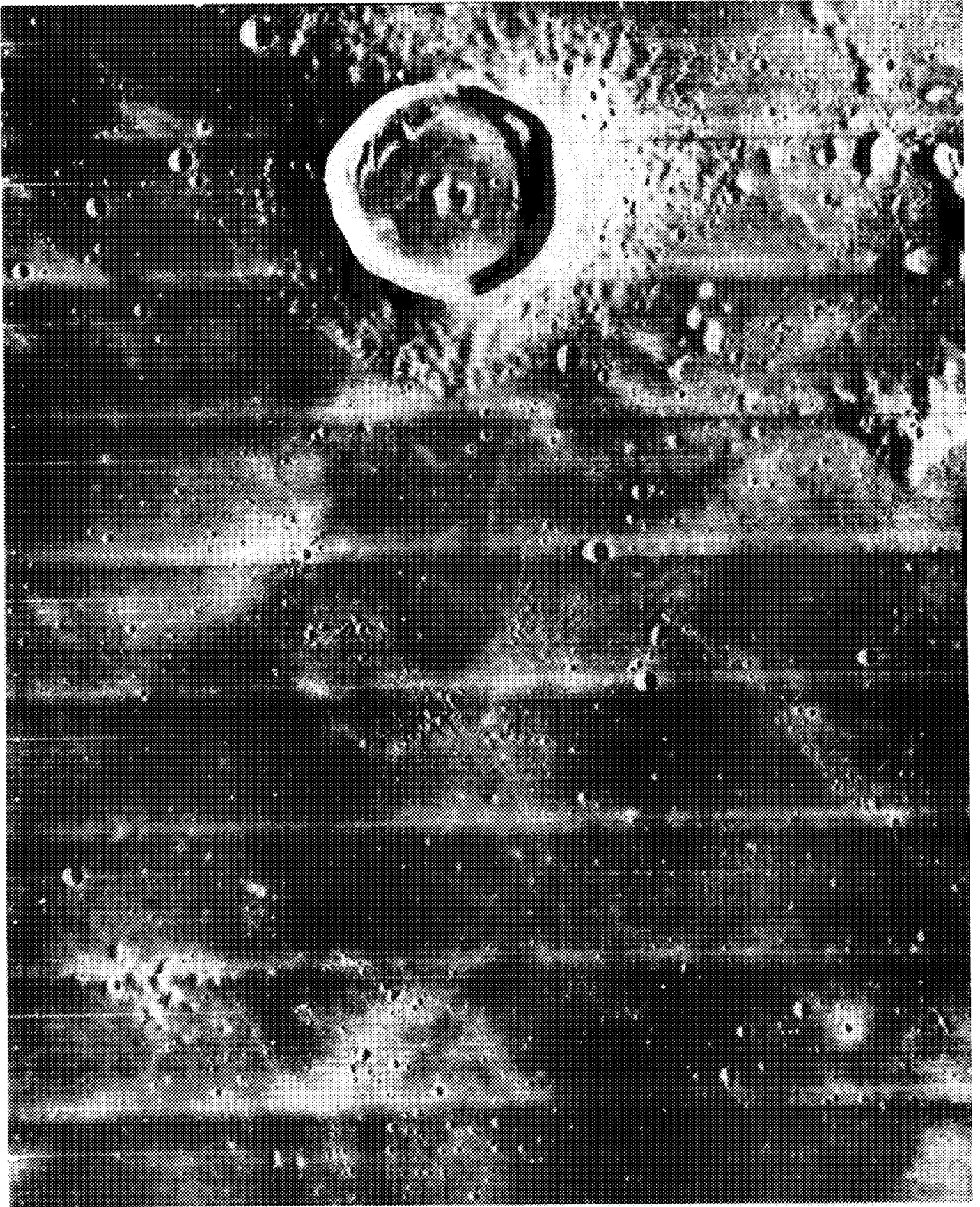


FIGURE 6 - FROM LUNAR ORBITER IV

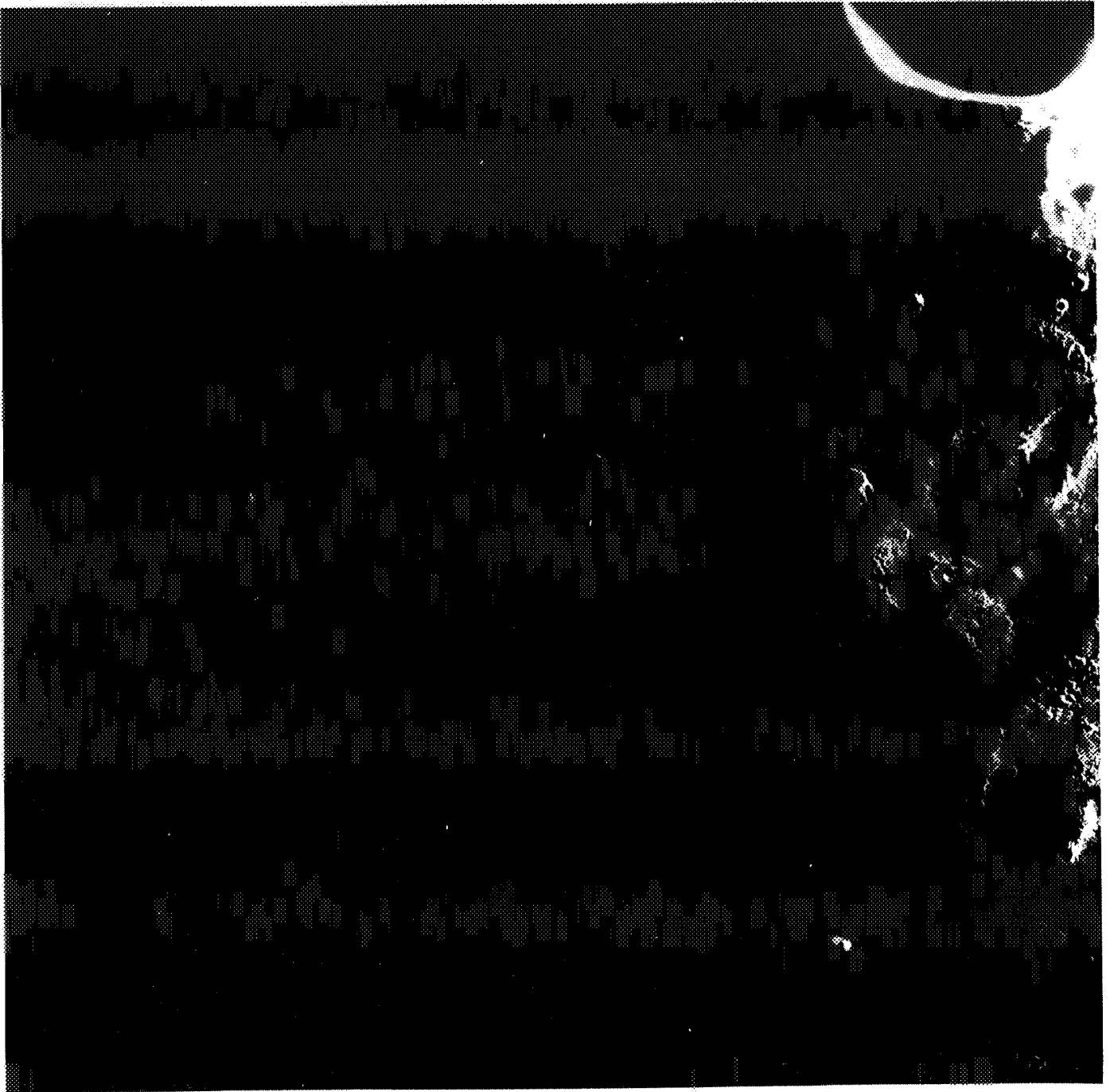


FIGURE 5 - AS14-78-10378